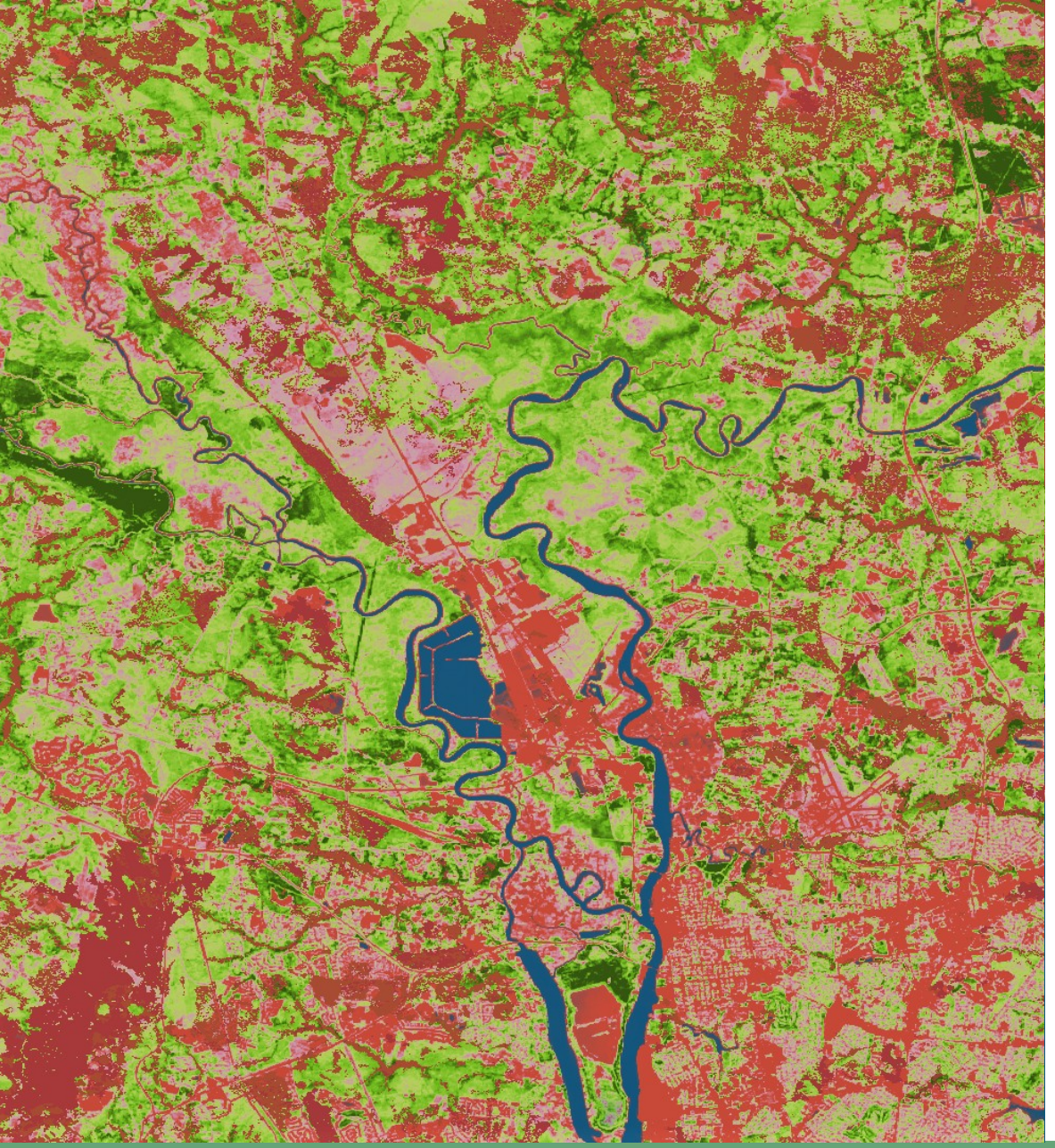


National Aeronautics and Space Administration

Carolina Coastal Plain

Ecological Forecasting

Utilizing NASA Earth Observations to Map Suitable Venus Flytrap Habitat to Inform Conservation Efforts, Seed Banking, and Reintroduction in the Carolina Coastal Plain and Sandhills Region

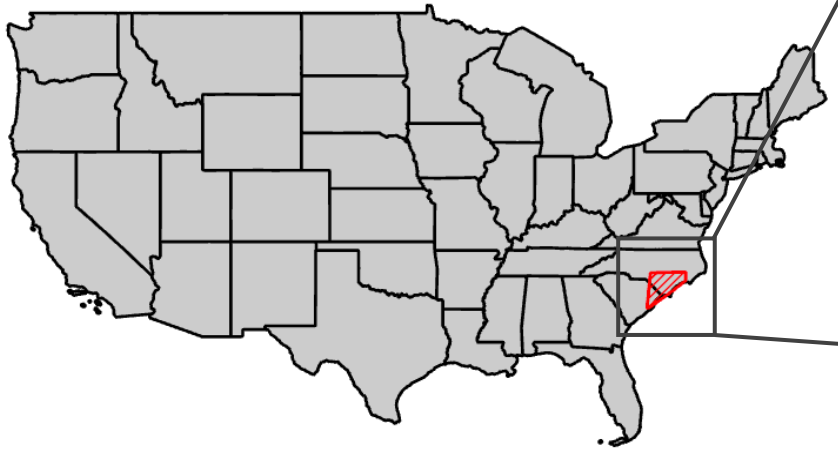
Monika Rock, Katie Caruso, Jayne Lampley, Ashna Siddhi, and Seamore Zhu

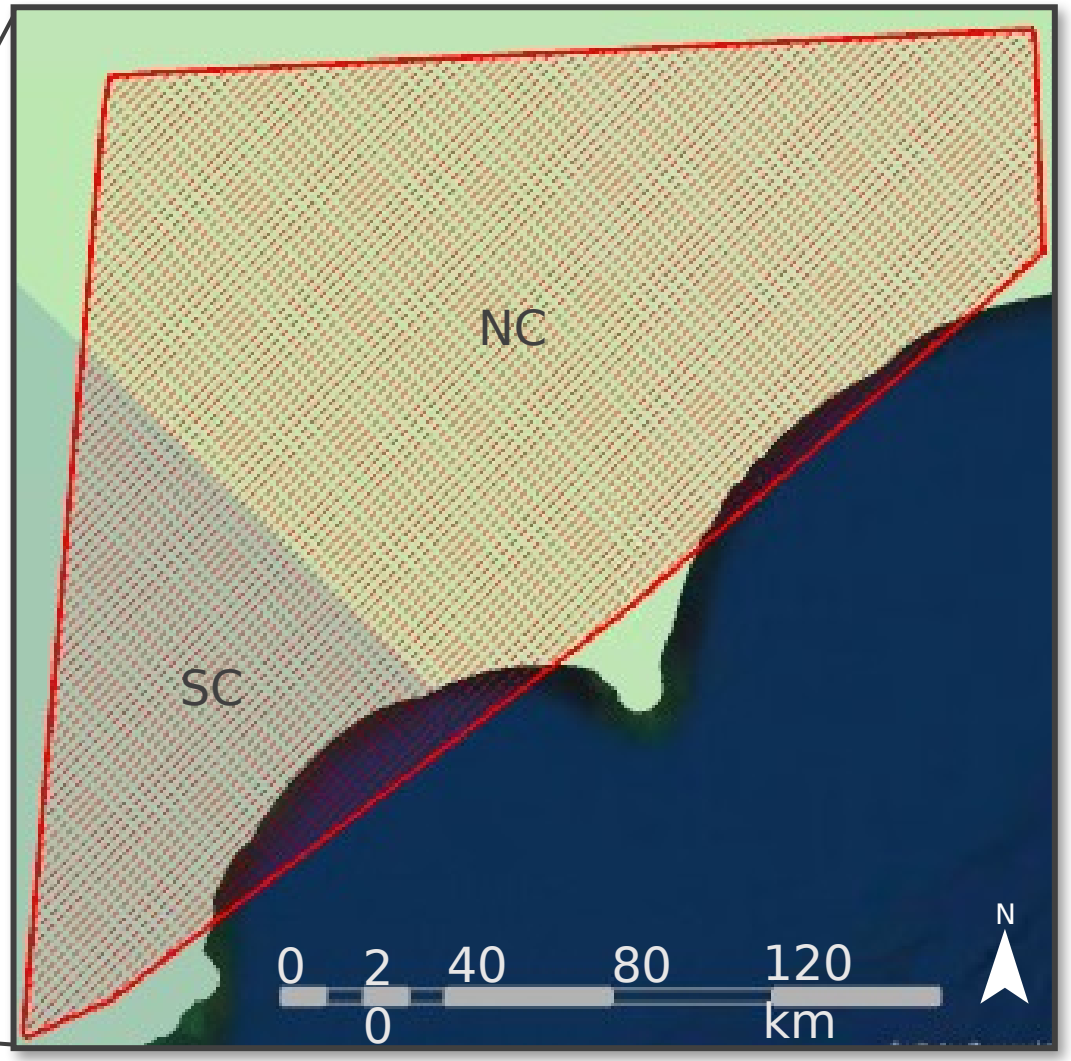
Georgia – | Fall 2021

DEVELOP

Study Area

- Convex polygon around current and all historic Venus Flytrap locations
- 10 km buffer to include any outliers
- Made in ArcGIS Pro - shapefile





Objectives

Applied Research

1 Generate 2021 HSM for VFT

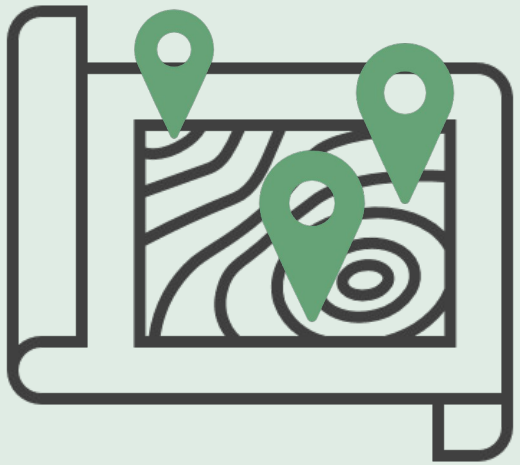
2 Generate 2050 land change map

Science Communication

3 Create public-facing StoryMap

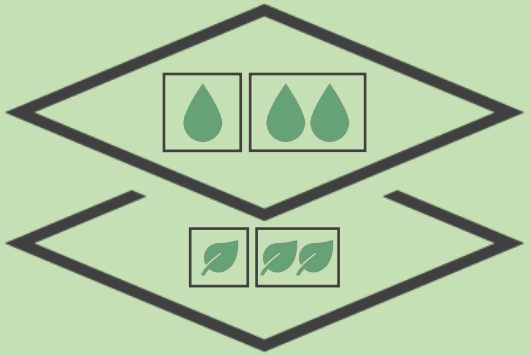
Key Concepts

Software for Assisted Habitat Modeling (SAHM)



HSM

Google Earth Engine, ArcGIS



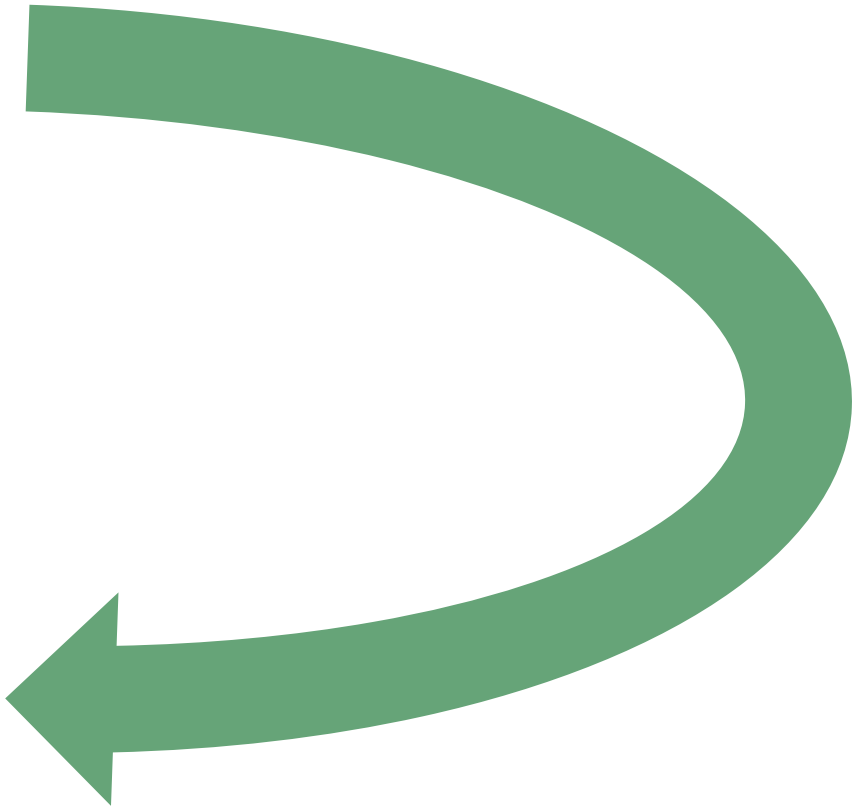
Predictor variables

TerrSet Land Change Modeler

Land change modeling

Methods: Habitat Suitability Model (HSM)

1. Gather Field Validation Points
2. Collection of Predictor Variables
3. Run Software for Assisted Habitat Modeling



Field Validation Points 1

- Over 400 polygons were gathered
- Data ranged back nearly 100 years
- 252 Points were kept for the model runs
  - Took out historic and low accuracy data

HSM

1

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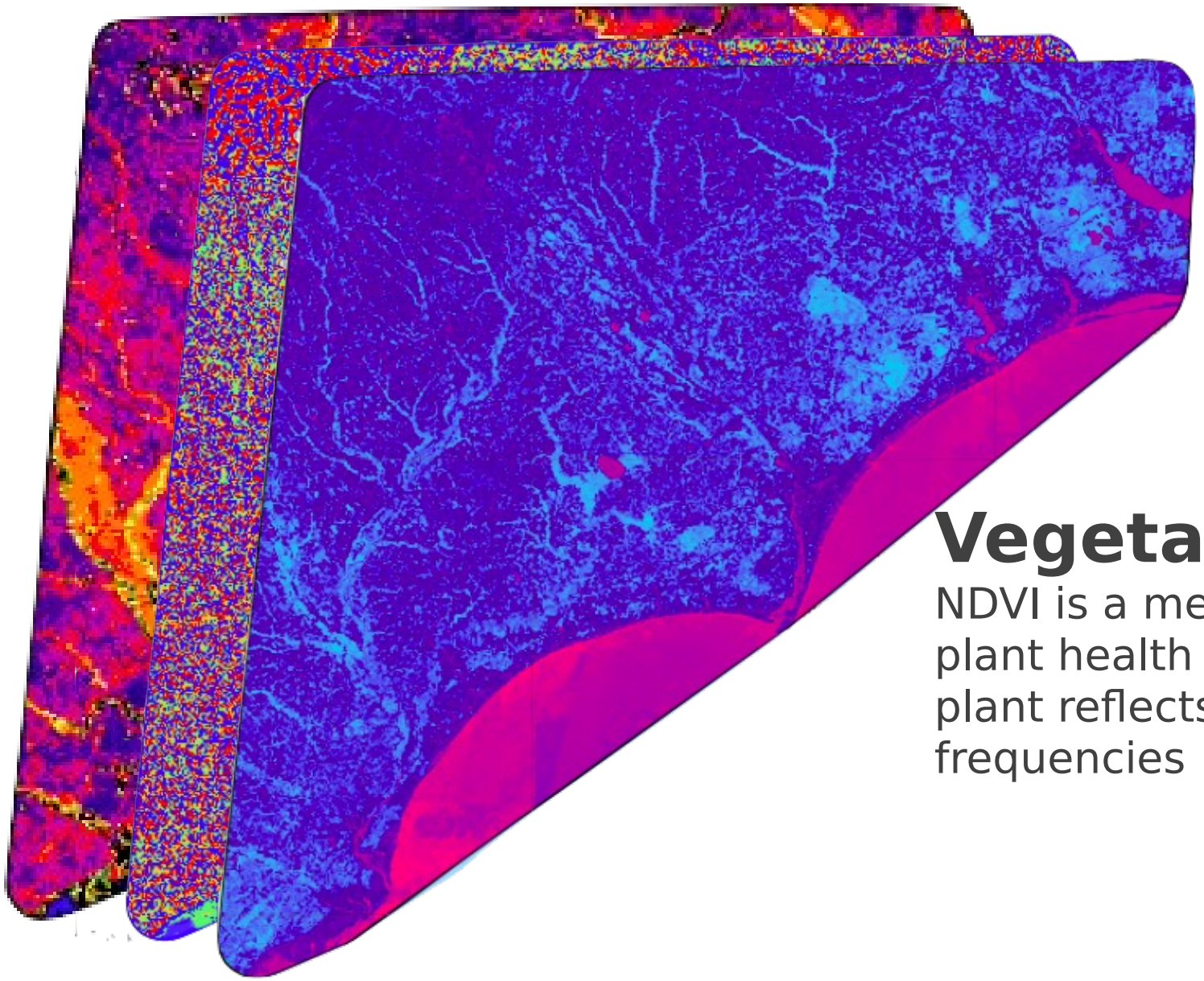
Methods: Predictor Variables



Vegetation Indices

NDVI is a measure of the state of plant health based on how the plant reflects light at specific frequencies

Methods: Predictor Variables

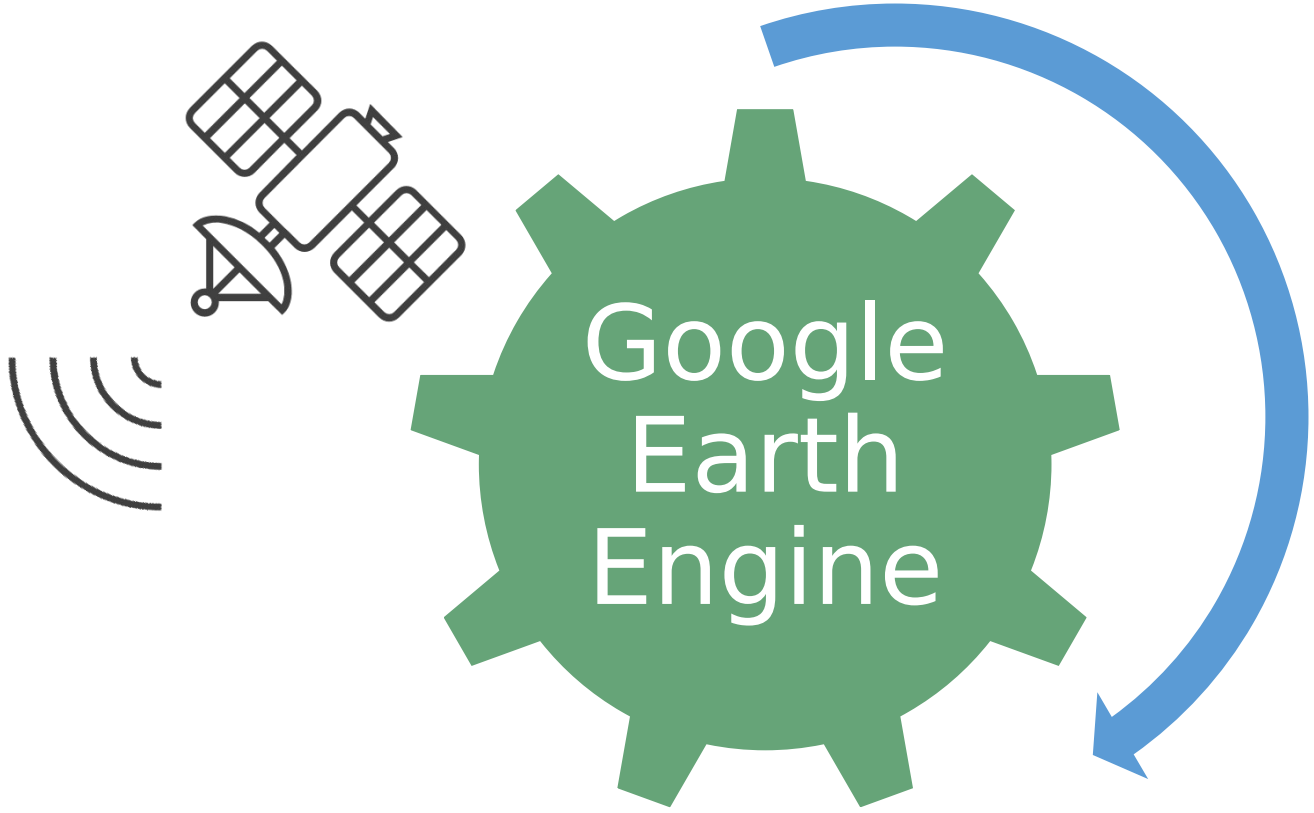


Image Credit: PowerPoint Stock Images

HSM

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Methods: Predictor Variables & Satellites

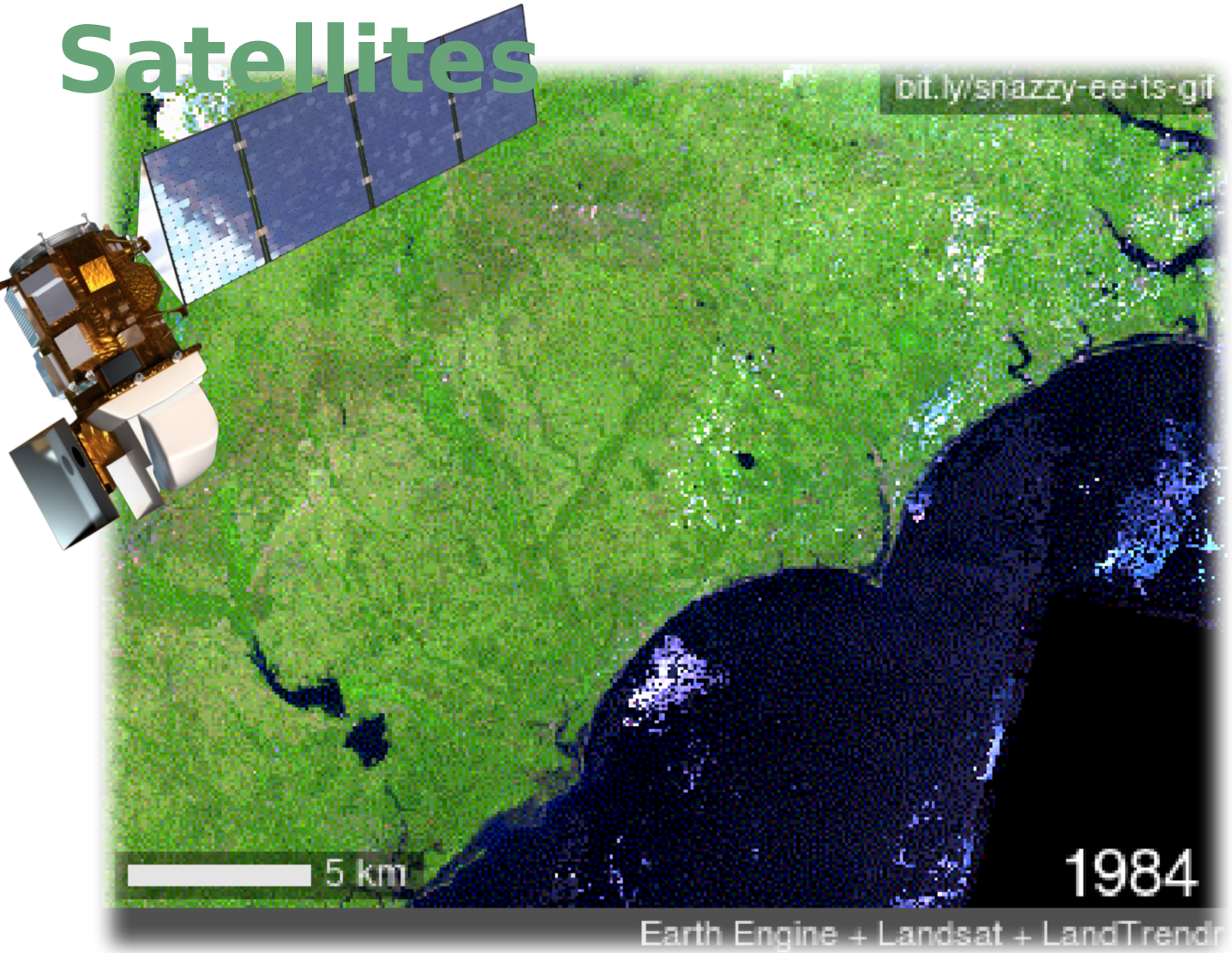

Image Credit: NASA & Earth Engine - LandTrender

Landsat 8 TIRS
- Surface temperature

Sentinel-2 MSI
- Vegetation indices

Terra MODIS
- Surface temperature

ALOS PASLAR
- Topographic variables

Ancillary datasets
- Soil
- Fire
- Land cover
- Canopy cover
- Precipitation

Methods: Predictor Variables

	SOURCE	SCALE/RES
Slope	JAXA's ALOS DSM	30m
Topographic Diversity (TD)	JAXA's ALOS DSM	30m
CHILI Continuous Heat Insolation Index	JAXA's ALOS DSM	30m
MTPI Multi-Scale Topographic Position Index	JAXA's ALOS DEM-AVE Band	30m
Precipitation	Climate Hazards Group CHIRPS	5566m
Soil Type (Taxonomic class)	USDA gSSURGO	10m
Available Water Storage 0-25cm	USDA gSSURGO	10m
Available Water Storage 25-50cm	USDA gSSURGO	10m
Flood Frequency Maximum	USDA gSSURGO	10m
Drainage Class	USDA gSSURGO	10m
Ponding Frequency (Presence)	USDA gSSURGO	10m
Water Table Depth (Apr-Jun Min.)	USDA gSSURGO	10m
Hydric Class	USDA gSSURGO	10m
Soil Moisture	USDA gSSURGO	10m

HSM

1

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Methods: Predictor Variables

	SOURCE	SCALE/RES
Mean Nitrogen (5, 15, 30 cm)	OpenLandMap ISRIC	250m
Soil pH (0, 10, 30 cm)	OpenLandMap ISRIC	250m
Soil Texture (0, 10, 30 cm)	OpenLandMap ISRIC	250m
Clay Content (0, 10, 30 cm)	OpenLandMap ISRIC	250m
Sand Content (0, 10, 30 cm)	OpenLandMap ISRIC	250m
Fire: % Low Severity	LANDFIRE	30m
Fire: % Mixed Severity	LANDFIRE	30m
Fire: % Replacement Severity	LANDFIRE	30m
Fire: Historical Mean Interval	LANDFIRE	30m
Fire: Historical Regimes	LANDFIRE	30m
Fire: Veg Departure from Historical	LANDFIRE	30m
Fire: Veg Succession Classes	LANDFIRE	30m
Fire: Veg Classes	LANDFIRE	30m
Land Cover	National Land Cover Database	30m

Methods: Predictor Variables

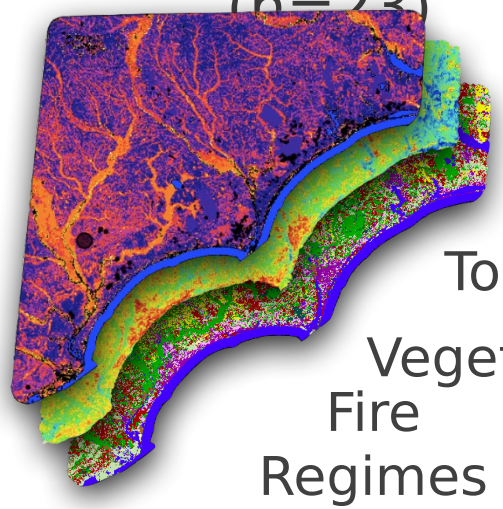
	SOURCE	SCALE/RES
Waterways GLCF: Landsat Global Inland Water	Landsat 8	30m
NDVI Normalized Differenced Vegetation Index	Sentinel-2	10m/30m
MSAVI2 Modified Soil Adjusted Vegetation Index	Sentinel-2	10m
NDWI Normalized Differenced Wetness Index	Sentinel-2 / Landsat	10m/30m
NLCD National Land Cover Database	GAP/CONUS	30m
Existing Vegetation Cover		30m
Tree Cover	Landsat 8 (For 2000, 2005, and 2010)	30m
Tassel-Cap Brightness	Sentinel-2	10m
Tassel-Cap Greeness	Sentinel-2	10m
Tassel-Cap Wetness	Sentinel-2	10m
Land Surface Temperature	Terra MODIS	250m
Land Surface Temperature	Landsat 8 TIRS	30m

Methods: Habitat Suitability Model (HSM)

Species Presence Points
(n=252)

+

Predictor Variables
(n=23)



Soil

Climate

Topography

Vegetation

Fire

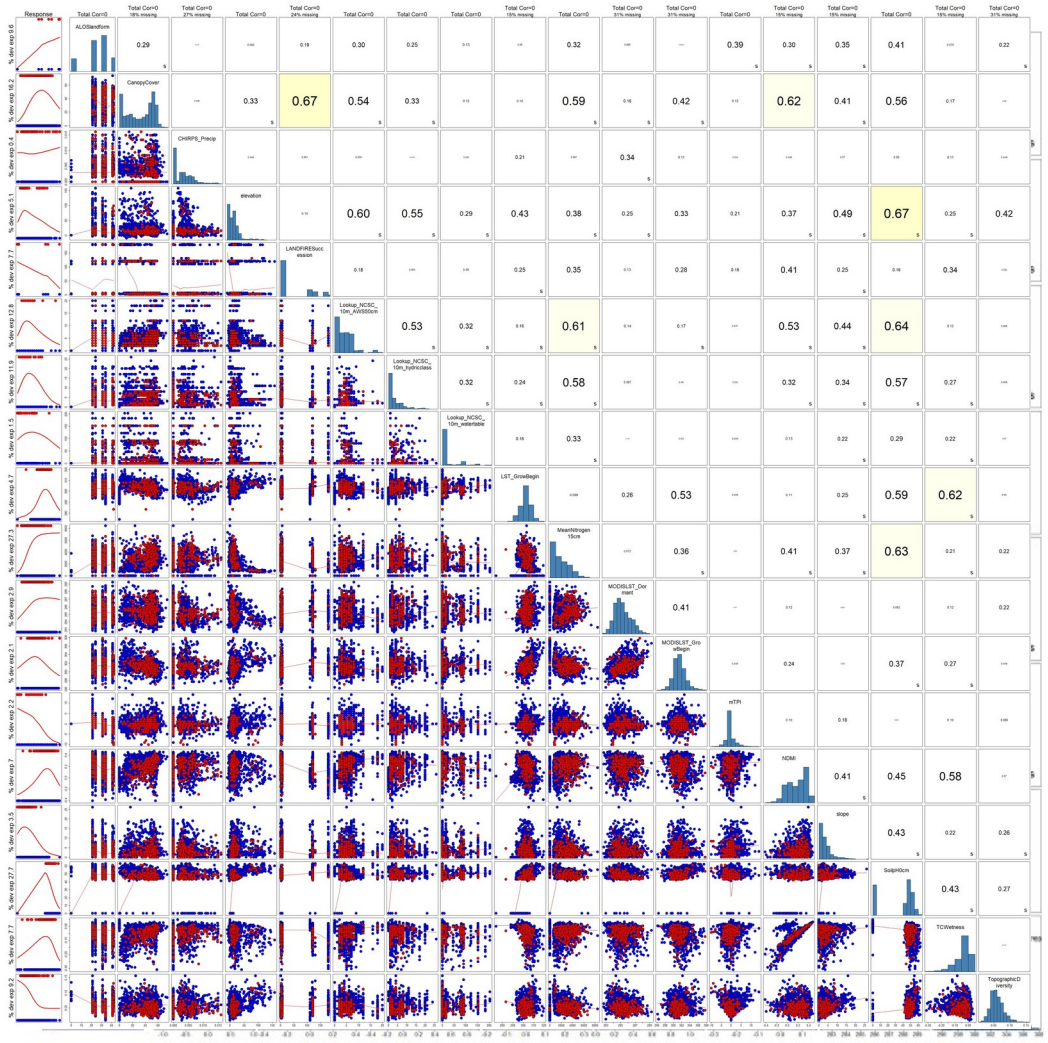
Regimes

Software for Assisted Habitat Modeling (SAHM)

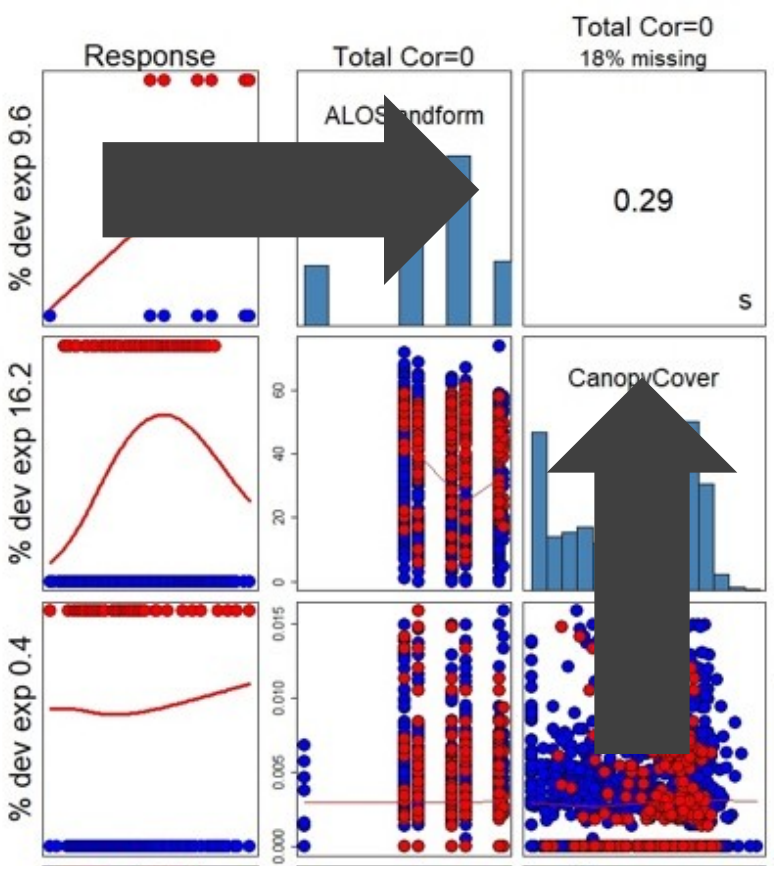
- Random Forest (RF)
- Generalized Linear Model (GLM)
- Boosted Regression Tree (BRT)
- Multivariate Adaptive Regression Splines (MARS)

Map of Suitable Habitat

Predictor Variables for Final Run



Covariate Correlation Display



Variable and Response

HSM

1

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Methods: Predictor Variables

	SOURCE	SCALE/RES
Elevation	JAXA's ALOS DSM	30m
Slope	JAXA's ALOS DSM	30m
Topographic Diversity (TD)	JAXA's ALOS DEM	30m
Landform	JAXA's ALOS DEM	
CHILI Continuous Heat Insolation Index	JAXA's ALOS DEM	30m
MTPI Multi-Scale Topographic Position Index	JAXA's ALOS DEM-AVE Band	30m
Precipitation	Climate Hazards Group CHIRPS	5566m
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Drainage Class	USDA gSSURGO	10m
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Water Table Depth (Apr-Jun Min.)	USDA gSSURGO	10m
Hydric Class	USDA gSSURGO	10m
Soil Moisture	USDA gSSURGO	10m

HSM

1

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Methods: Predictor Variables

	SOURCE	SCALE/RES
Hydric Class	USDA gSSURGO	10m
Soil Moisture	USDA gSSURGO	10m
Mean Nitrogen (5, 15, 30 cm)	OpenLandMap ISRIC	250m
Soil pH (0, 10, 30 cm)	OpenLandMap ISRIC	250m
Soil Texture (0, 10, 30 cm)	OpenLandMap ISRIC	250m
Clay Content (0, 10, 30 cm)	OpenLandMap ISRIC	250m
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Fire: % Low Severity	LANDFIRE	30m
Fire: % Mixed Severity	LANDFIRE	30m
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Fire: Historical Mean Interval	LANDFIRE	30m
Fire: Historical Regimes	LANDFIRE	30m
Fire: Veg Departure from Historical	LANDFIRE	30m
Fire: Veg Succession Classes	LANDFIRE	30m
Fire: Veg Classes	LANDFIRE	30m

HSM

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Methods: Predictor Variables

	SOURCE	SCALE/RES
Land Cover	National Land Cover Database	
Waterways GLCF: Landsat Global Inland Water	Landsat 8	30m
NDVI Normalized Differenced Vegetation Index	Sentinel-2	10m/30m
MSAVI2 Modified Soil Adjusted Vegetation Index	Sentinel-2	10m
NDWI Normalized Differenced Wetness Index	Sentinel-2 / Landsat	10m/30m
NLCD Vegetation	GAP/CONUS	30m
Existing Vegetation Cover		30m
Tree Cover	Landsat 8 (For 2000, 2005, and 2010)	30m
Tassel-Cap Brightness	Sentinel-2	10m
Tassel-Cap Greeness	Sentinel-2	10m
Tassel-Cap Wetness	Sentinel-2	10m
Land Surface Temperature	Terra MODIS	250m
Land Surface Temperature	Landsat 8 TIRS	30m

Methods: Future Modeling

1. TerrSet: Land Change Modeler
2. Collection of Future Predictor Variables
3. Run Software to Generate Future Potential Map

FM

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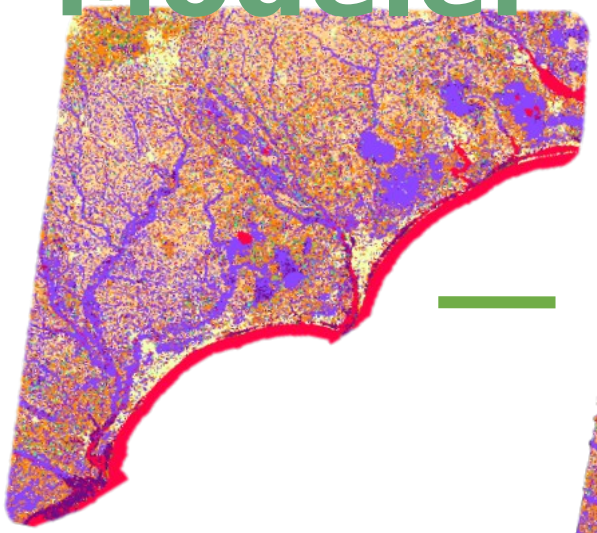
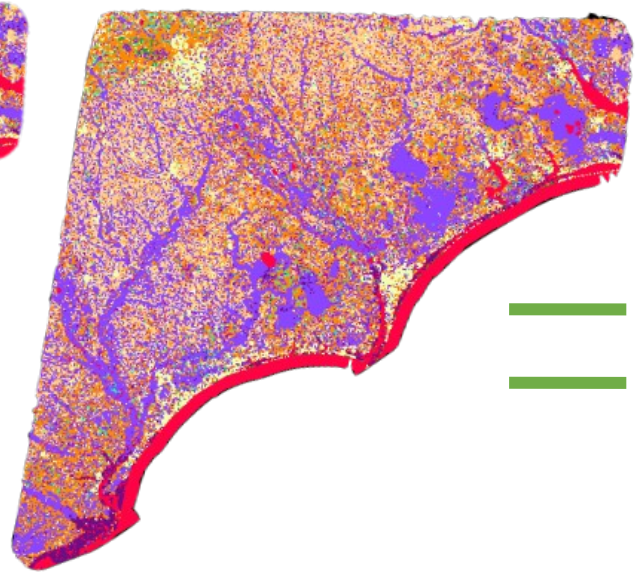
Methods: TerrSet Land Change Modeler

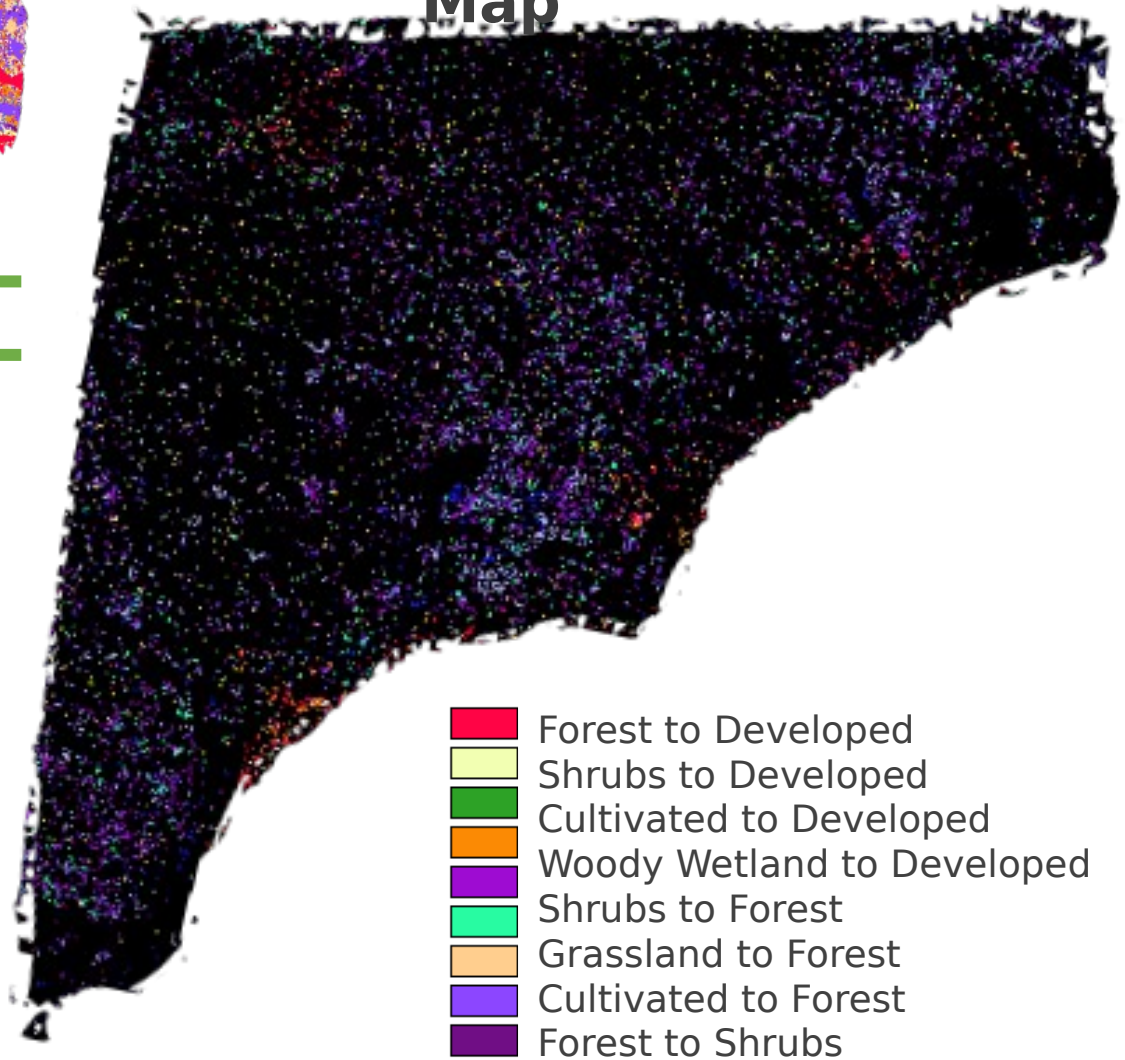
2001 Land Cover



2019 Land Cover



Land Cover Change Map



- Open Water
- Developed
- Barren Land
- Forest
- Shrubs
- Grassland
- Cultivated/Planted
- Woody Wetland
- Herbaceous Wetland

- Forest to Developed
- Shrubs to Developed
- Cultivated to Developed
- Woody Wetland to Developed
- Shrubs to Forest
- Grassland to Forest
- Cultivated to Forest
- Forest to Shrubs

FM

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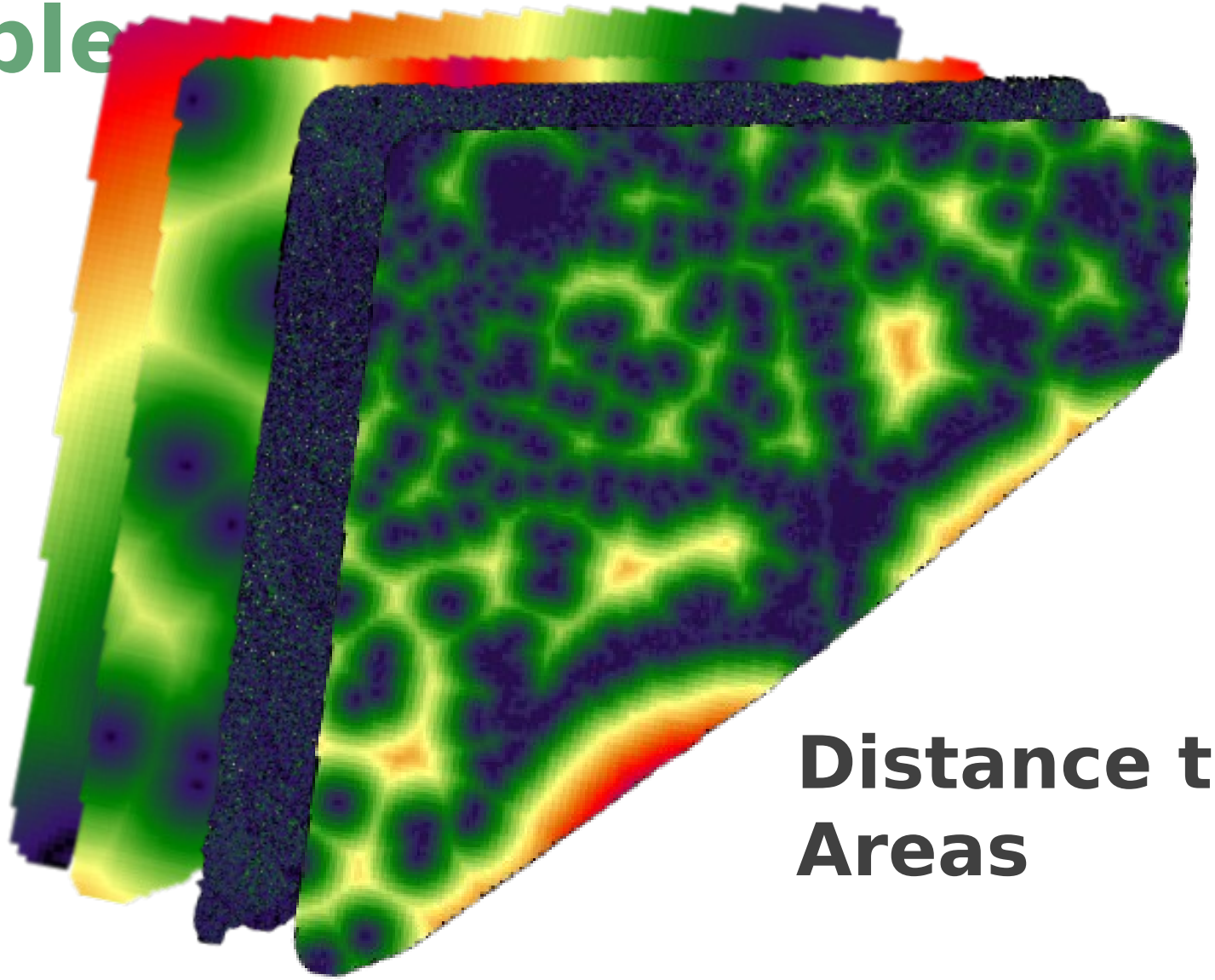
Methods: Explanatory Predictor Variable



Distance to Urban Areas

FM

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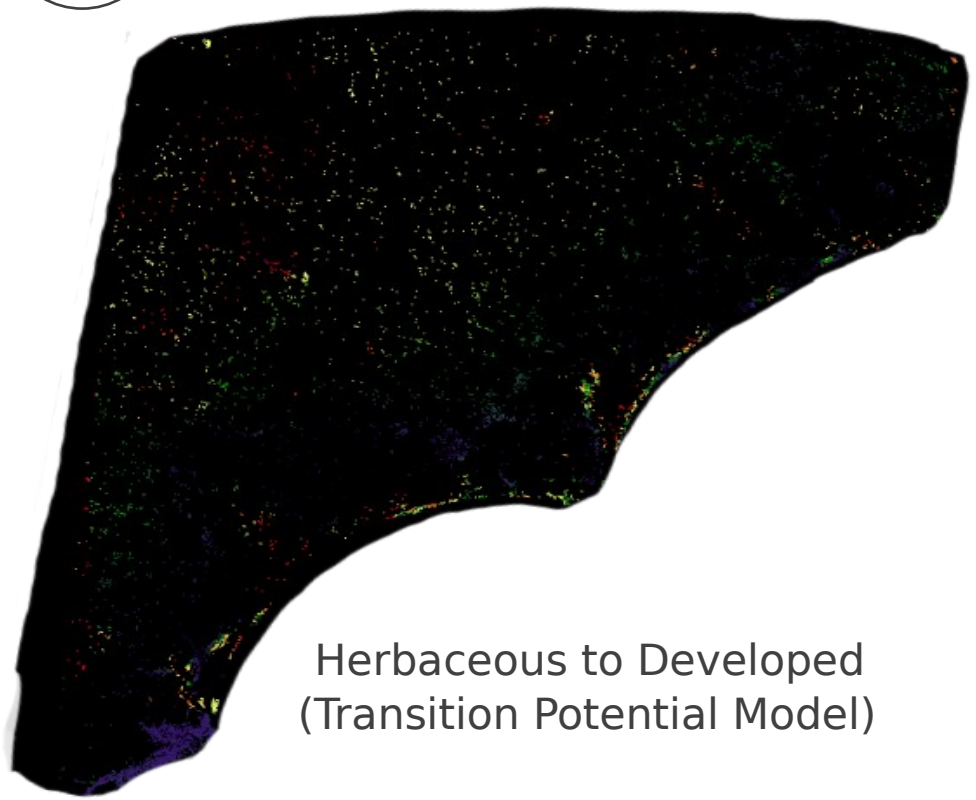
Methods: TerrSet Land Change Modeler

1. Two landcover maps
2. Predictor variables



Herbaceous to Developed
(Transition Potential Model)

HOW IT WORKS

- Random sample of pixel that experienced the change is created as a training site
- Weights are applied to each variables
- Quantity of change in each transition is modeled

MODELS RUN

- Multi-Layer Perceptron (MLP)

OUTPUT

- Transition Potential Models
- Future Potential Transition Map

FM

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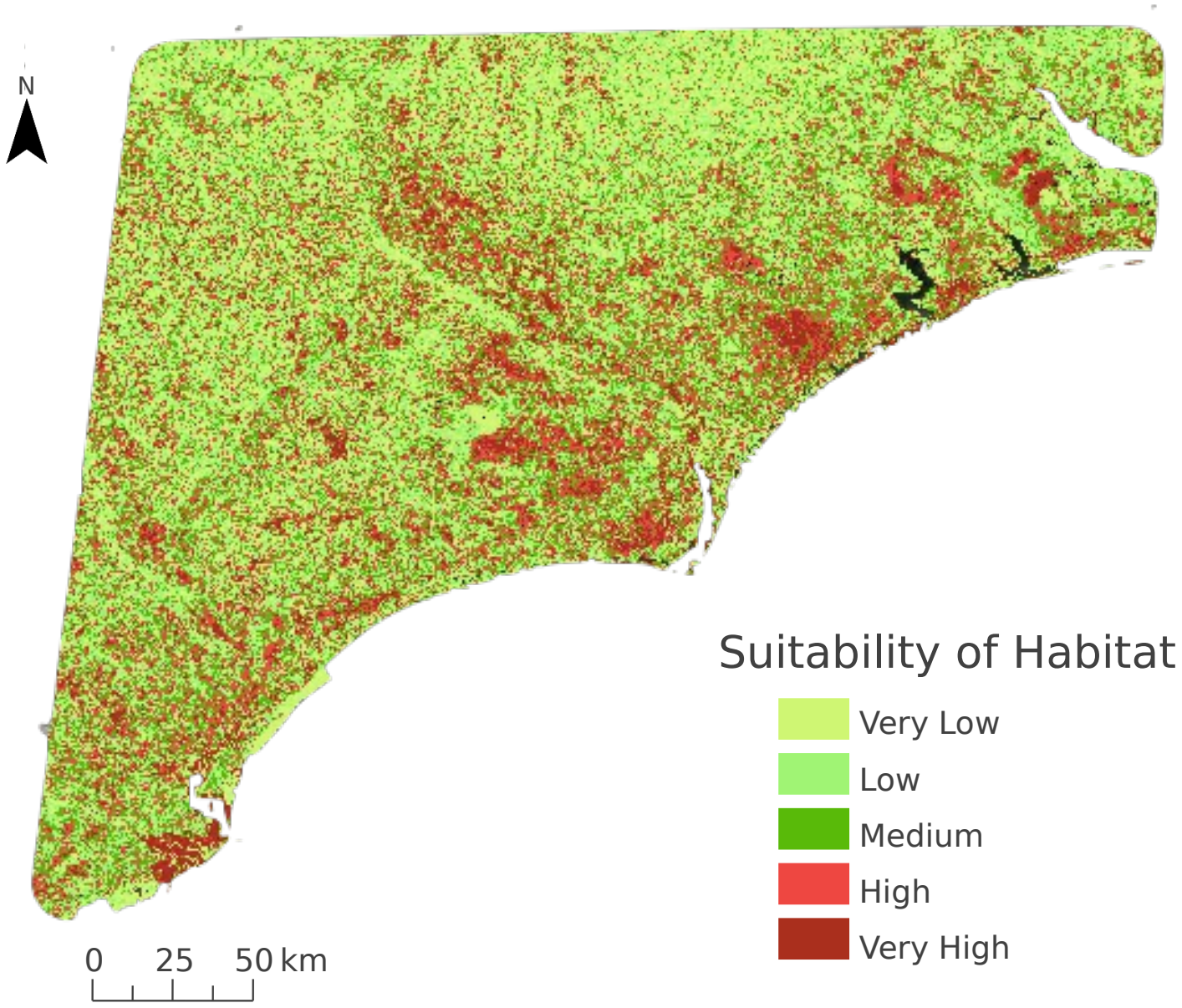
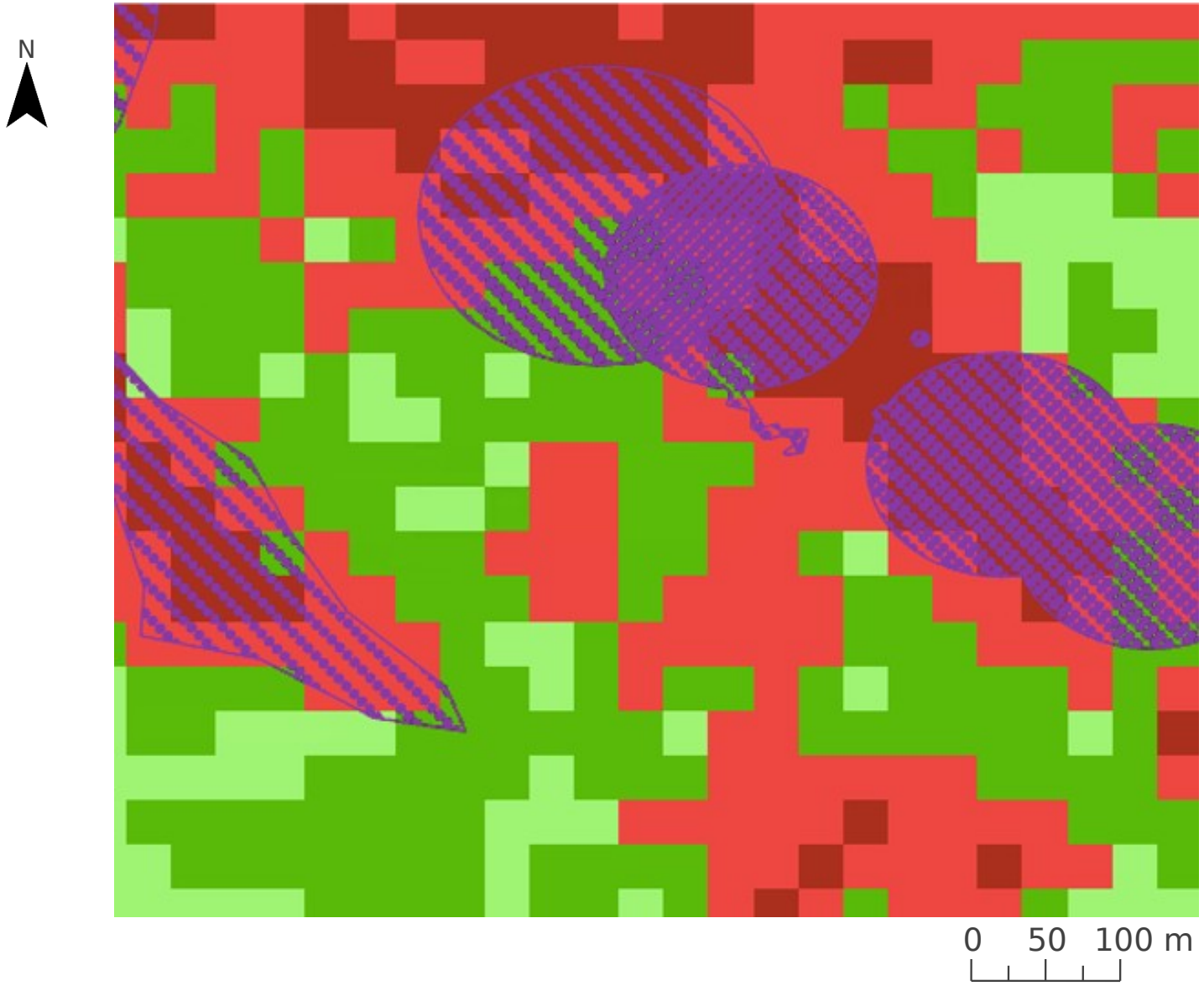
Results: 2021 BRT HSM



Important Variables:

- Soil data
- LANDFIRE
- Topography
- NDMI
- Vegetation indices

Results: 2021 BRT HSM



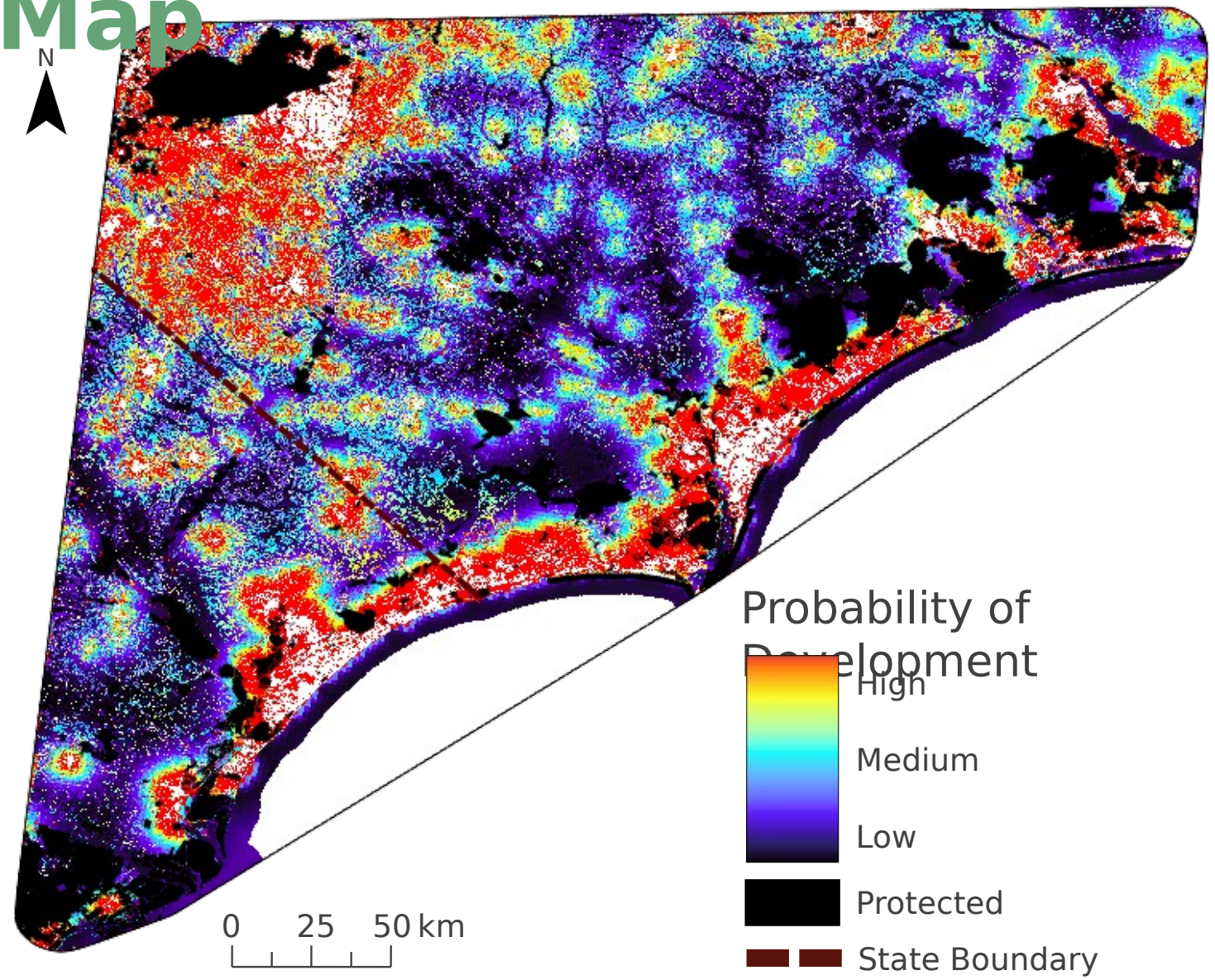
Important Variables:

- Soil data
- LANDFIRE
- Topography
- NDMI
- Vegetation indices

Suitability of Habitat

- Presence Data
- Very Low
- Low
- Medium
- High
- Very High

Results: 2050 Potential Transition Map

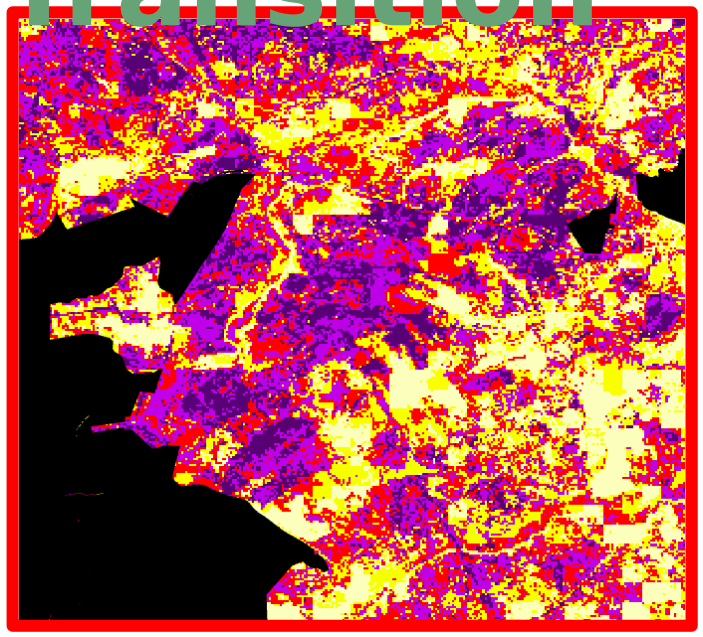


Factors Driving Development:

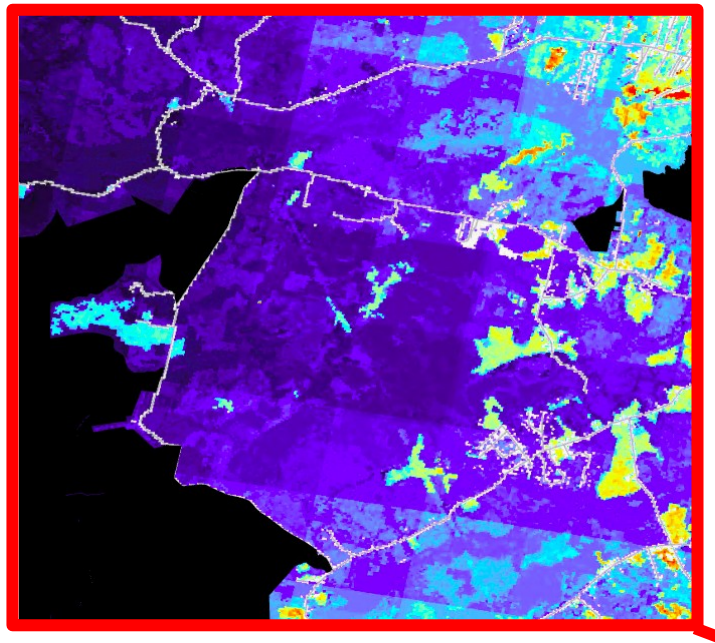
- Proximity to coast
- Proximity to current cities
- Proximity to golf courses

Results: Comparing HSM & Potential Transition

HSM

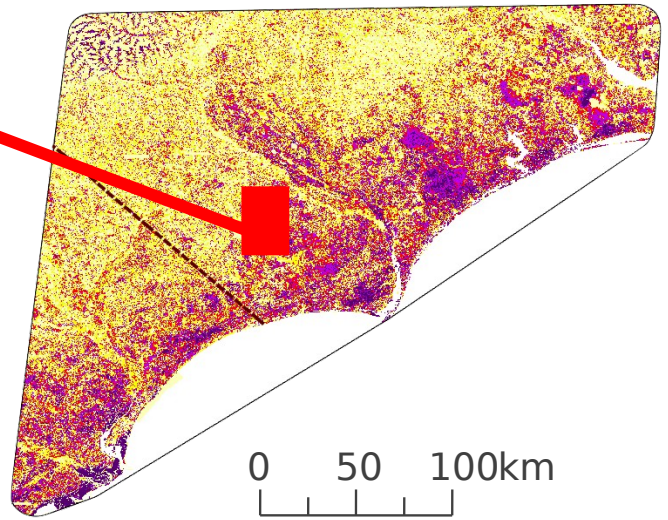


Potential Transition



0 0.5 1km

Areas with suitable habitat and low probability of being developed



Suitability of Habitat

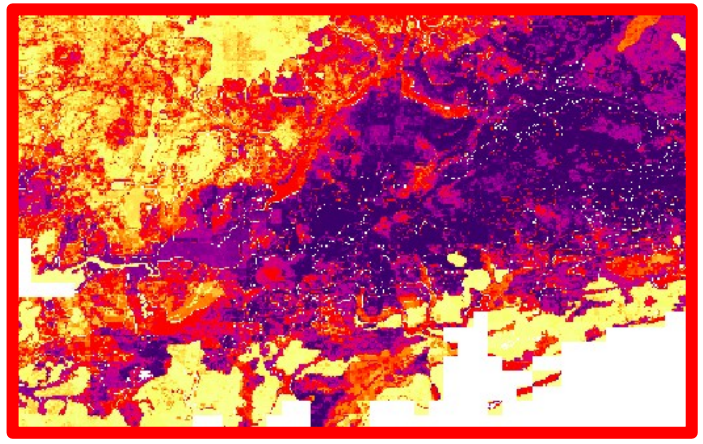
- Very Low
- Low
- Medium
- High
- Very High

Probability of Development

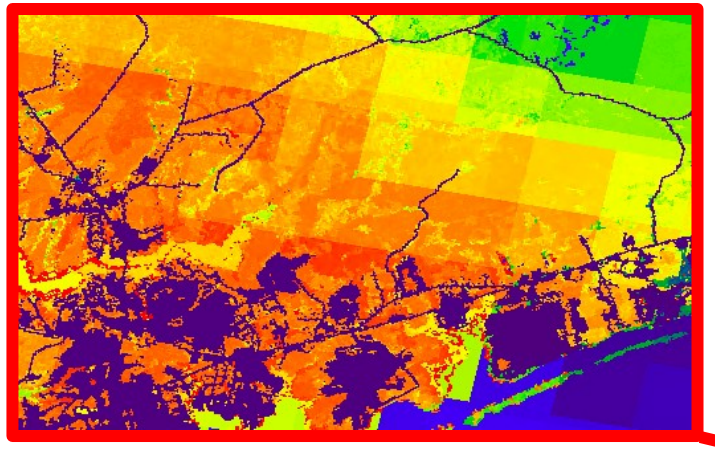
- High
- Medium
- Low
- Protected

Results: Comparing HSM & Potential Transition

HSM



Potential Transition



0 2.5 5 km

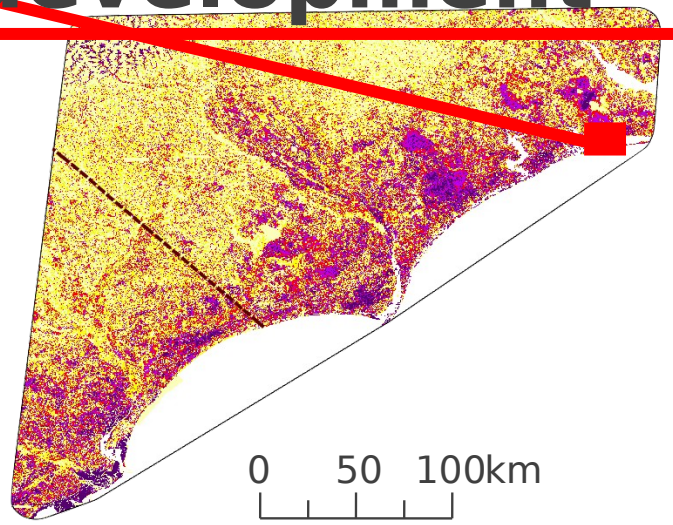
Suitability of Habitat

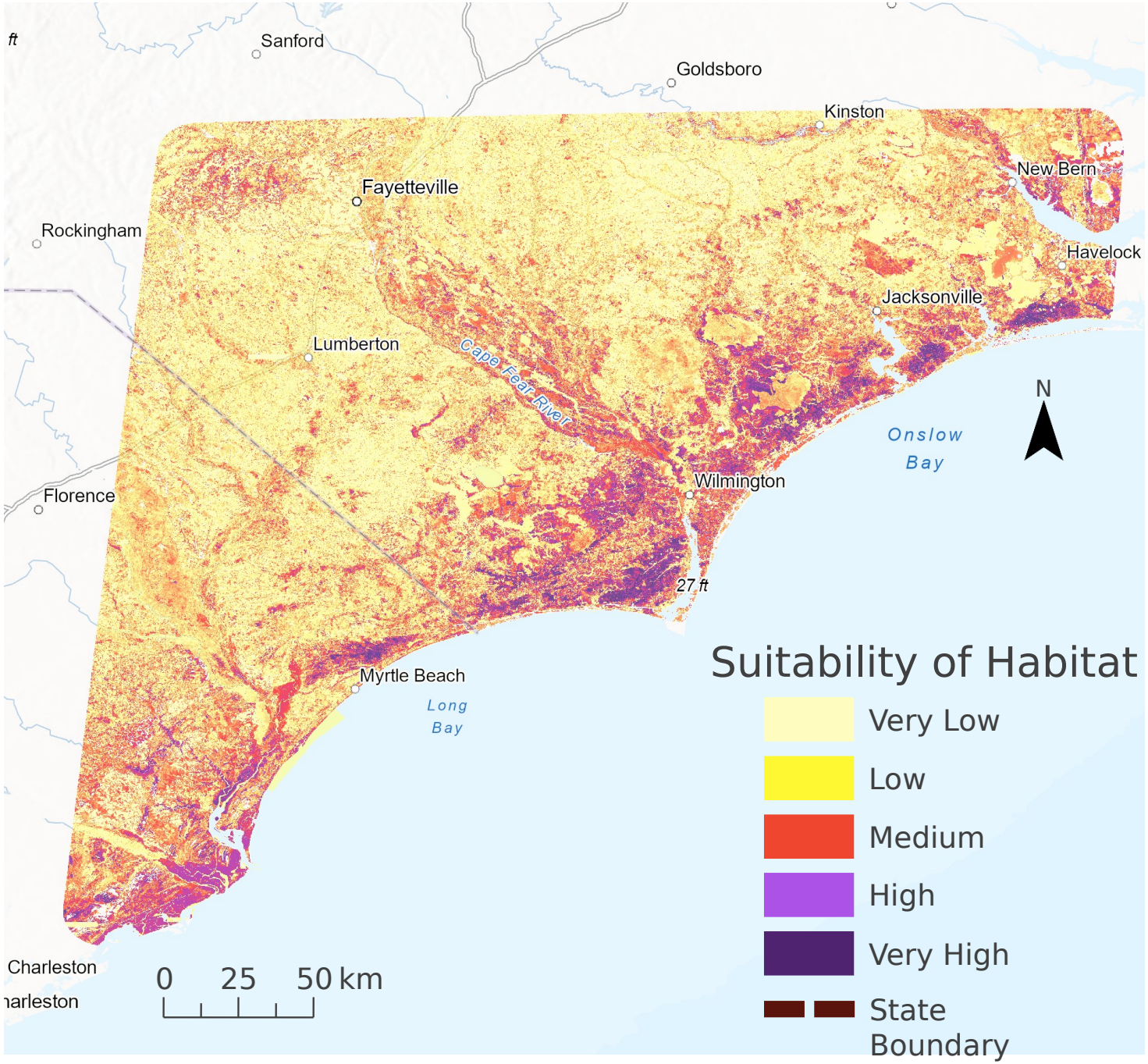
- Very Low
- Low
- Medium
- High
- Very High

Probability of Development

- High
- Medium
- Low
- Protected

Areas showing future conflict between suitable habitat and development

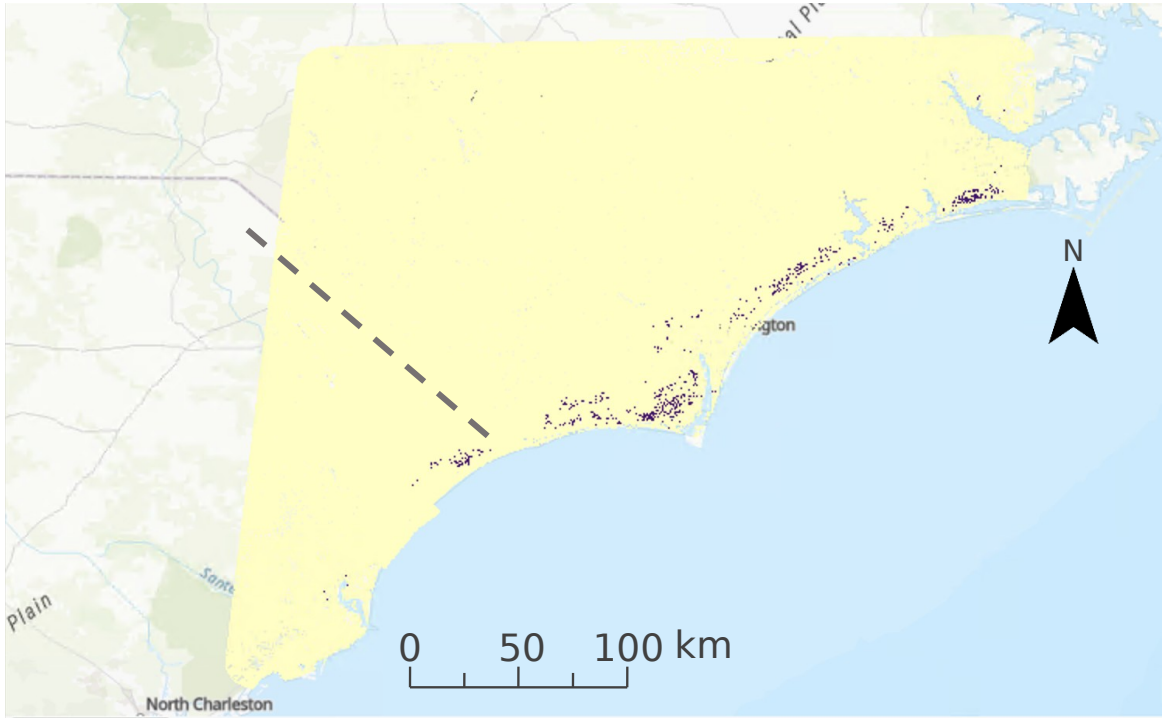



Sanford
Goldsboro
Kinston
New Bern
Fayetteville
Rockingham
Havelock
Jacksonville
Lumberton
Cape Fear River
N
Onslow Bay
Wilmington
Florence
27 ft
Myrtle Beach
Long Bay
Charleston
0 25 50 km
Suitability of Habitat
Very Low
Low
Medium
High
Very High
State Boundary

Results: Areas of Potential Conflict

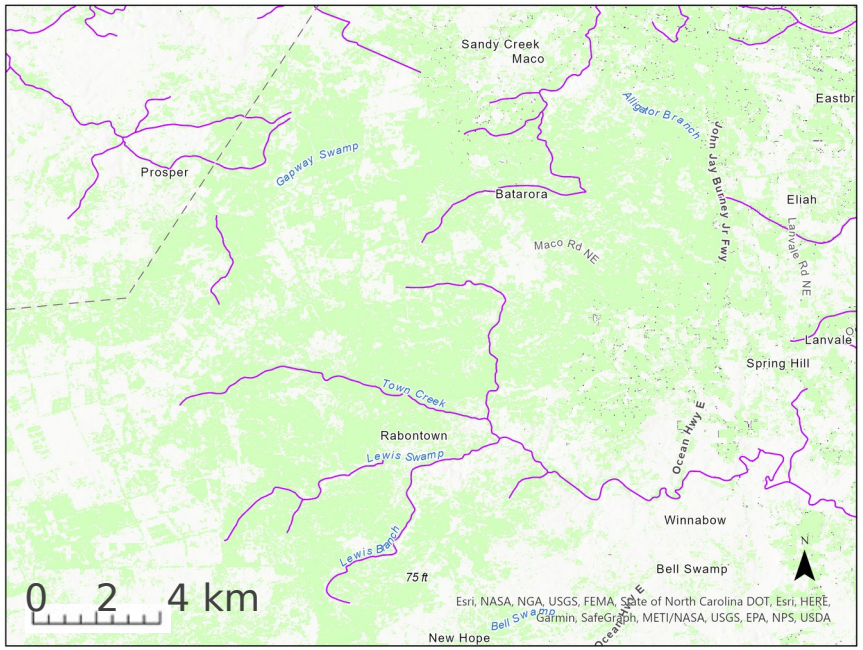
Comparing the 2021 BRT HSM and 2050 Potential Transition Map

	Area
>90% Probability Suitable Habitat	330 km²
>50% Land Change Potential by 2050	7788 km²
Overlap between predicted suitable habitat and development potential	178 km²



53.8% of predicted suitable habitat threatened by development by 2050

Results: Potential Venus Flytrap Sites



Suitable Habitat

- Most Likely
- Least Likely
- Conflict Areas

- Rabontown, northern Brunswick Co., NC, west of Wilmington
- Bladen Co., NC near Colly Creek
- Pender Co., NC surrounding Angola Bay Gameland in Northeast Cape Fear River watershed
- Georgetown and Marion Counties, Vicinity of Williams Hill and Woodbury, SC in the Great PeeDee River watershed

Results: Populations at Potential Risk

- Northeastern New Hanover County site – Kirkland, NC near I-140
- Holly Ridge area sites – Onslow Co., NC
- Southeastern Pender County, NC sites
- Boiling Spring Lakes: Orton Creek, NC

Credit: Johnny Randall

CONCLUSIONS

- SAHM and TerrSet programs can be used to map current suitable habitat and areas that will be most impacted by development in the future for Venus flytraps
- Niche modeling can provide partners with useful information to help inform land management

Credit: NCBG

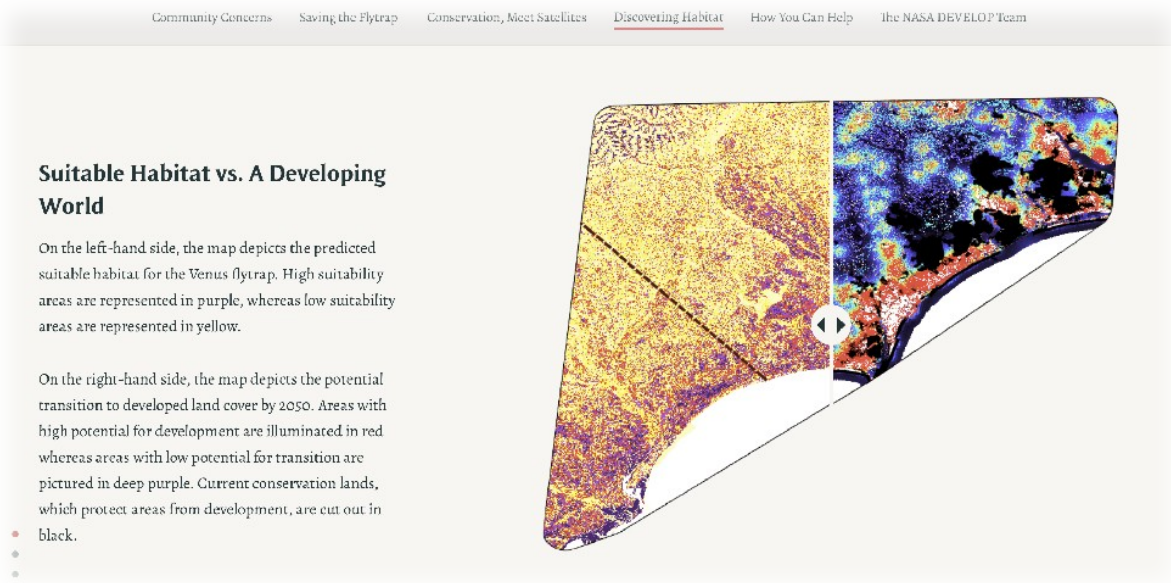
LIMITATIONS

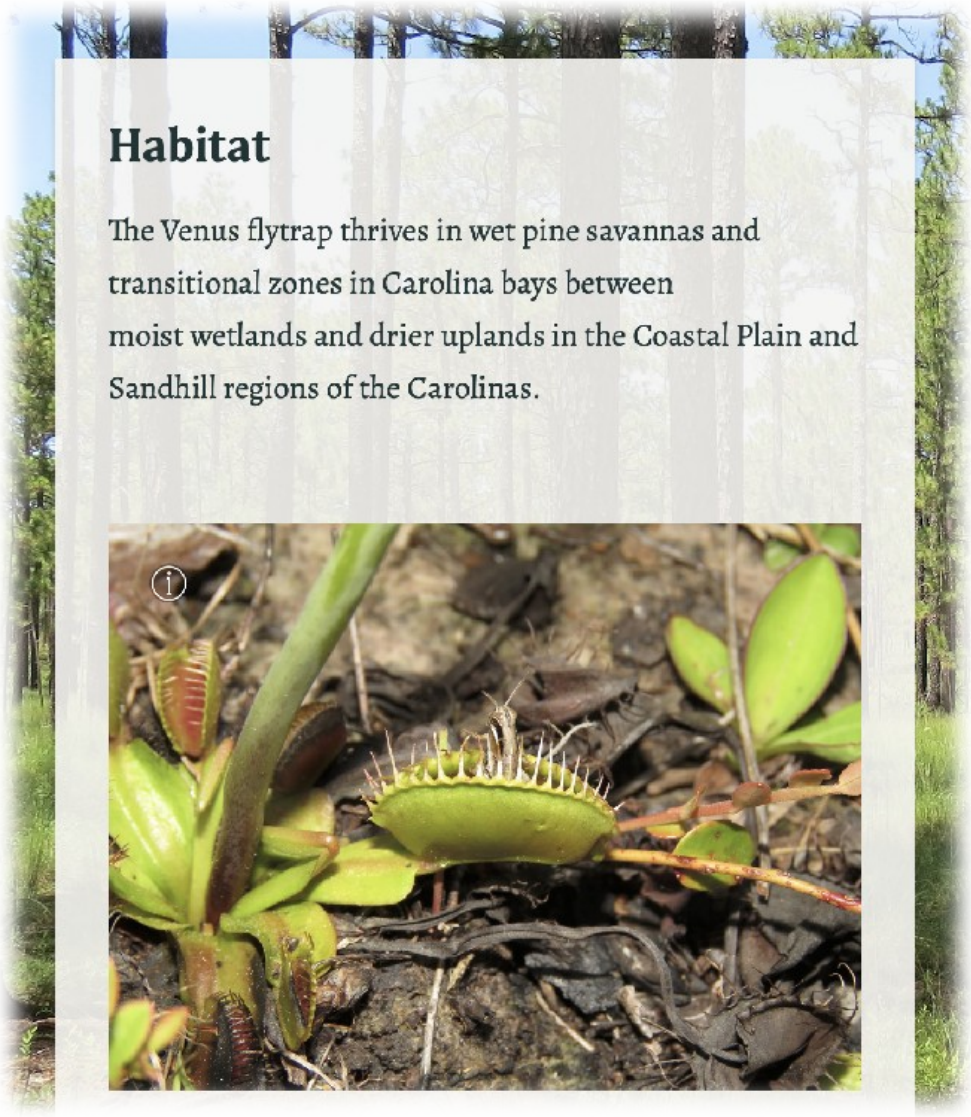
- Study area may not have included full historic range of species
- Presence-only points in SAHM
- Population size not accounted
- Natural land cover transitions in TerrSet
- Time restraints on models

Credit: Clyde Sorenson

Science Communication & Outreach

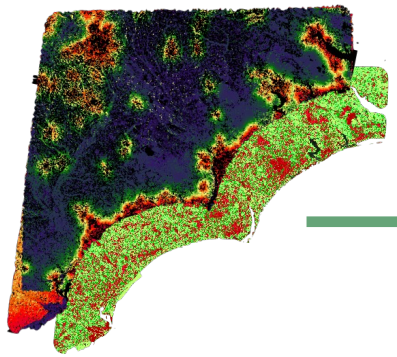
Credit: Mnolf





Credit: Clyde Sorenson

FUTURE WORK



Land protection/ reintroduction

Associat e species

Coastal Plain/ Sandhills Habitats

Survey for new

Develop 2050

Expand study area

Image Credits: Johnny Randall, Clyde Sorenson, Natalie Kerr

HANDOFF – WHAT YOU'LL RECIEVE

- This PowerPoint & our Closeout PowerPoint
- StoryMap
- Tech Paper - goes into detail of our methods if you wanted to rerun models, & goes over final model results
- Raster Files - Study Area, Final Habitat Suitability Model, & Future Model (can be opened in ArcMap)
- Printable Final Map

ACKNOWLEDGEMENTS

- Dr. Marguerite Madden, Science Advisor, University of Georgia Athens
- Sarah Payne, NASA DEVELOP Fellow
- Dr. Johnny Randall, Project Partner, North Carolina Botanical Garden
- Dr. Damon Waitt, Project Partner, North Carolina Botanical Garden
- Misty Buchanan, Project Partner, North Carolina Natural Heritage Program
- Dr. Alan Weakley, Project Partner, University of North Carolina at Chapel Hill Herbarium
- Meredith Wojcik, North Carolina Natural Heritage Program
- Dale Suiter, U.S. Fish and Wildlife Service
- Sarah McRae, U.S. Fish and Wildlife Service
- Stephanie Horton, North Carolina Natural Heritage Program

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ACKNOWLEDGEMENTS

- Joseph Lemeris, South Carolina Natural Heritage Program
- Keith Bradley, South Carolina Natural Heritage Program
- Dr. Clyde Sorenson, North Carolina State University
- Dr. Natalie Kerr, Duke University
- Laura Hamon, North Carolina State University
- Julie Moore, Venus Flytrap Champions
- Peder Engelstad, Colorado State University
- Alex Posen, NASA DEVELOP
- Dr. Kenton Ross, Mentor NASA DEVELOP National Program Office
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This material contains modified Copernicus Sentinel data (2020 – 2021), processed by ESA.

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Back-up Slides / Extras

Key Concepts

Credit: Johnny Randall

Habitat Suitability Model (HSM)

Predictor Variables

Land Change Modeling

FIELD VALIDATION DATA

- Over 400 field validation points
- Data goes back almost 100 years
- Data was gathered from NC and SC

Image Credit: Clyde Sorenson

HSM

1

2

3